

## CHARACTERISTICS OF SITES OCCUPIED BY SUBSPECIES OF *ARTEMISIA TRIDENTATA* IN THE PICEANCE BASIN, COLORADO

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*Key words:* *Artemisia tridentata*, Colorado, sagebrush, chromatography, factor analysis, soil.

*Artemisia tridentata*, big sagebrush, is the dominant plant species in the Piceance Basin of western Colorado and displays great morphological variability between sites. The existence of at least three subspecies is widely accepted (McArthur et al. 1981, 1988). These are *A. tridentata* spp. *tridentata* Beetle, *A. tridentata* spp. *wyomingensis* Beetle and Young, and *A. tridentata* spp. *vaseyana* Beetle.

Despite extensive research in the Piceance Basin (Redente and Cook 1986), we have found only one study referring to intraspecific taxa of sagebrush (Ward et al. 1985). This work referred to subspecies *tridentata* but did not indicate where this taxon was found. Because the taxa are known to respond differentially to soil and climate factors (Hironaka 1978, Sturges 1978) their existence in the basin should be recognized. The present study was designed to identify the subspecies of *Artemisia tridentata* present in the Piceance Basin and to describe soil characteristics of sites occupied by subspecies.

### STUDY SITE

The Piceance Basin comprises about 3000 km<sup>2</sup> in Garfield and Rio Blanco counties of northwest Colorado (Fig. 1). The climate of the Piceance Basin is semiarid and shows extreme variability in monthly precipitation (Wymore 1974). Consecutive months often receive little precipitation. The mean annual precipitation for eight weather stations in the region for the period 1951–70 was 35.3 cm, with a 95% confidence interval of  $\pm 18.7$  cm. About one-half of the total precipitation falls as snow. The average

annual temperature ranges from 7 C at 1800 m to -1 C at 2700 m.

The strong influence of topography on temperature and precipitation results in a complex of habitats in the basin (Tiedeman and Terwilliger 1978). Generally, soil development is correlated to elevation. At higher elevations, except ridge tops, soils are dark brown, shallow mollisols. At mid-elevations, aridisols are common on deep loess. The lowest elevations are characterized by entisols developed on heavy clays and deep, sandy alluvial soils.

### METHODS

Six sites dominated by sagebrush were selected for this study (Table 1). These sites spanned the environmental extremes of sagebrush habitat in the Piceance Basin. Two sites were selected from each of three broad topographic regions. High mountain sites were about 2000 m; upland terraces and valley bottom sites were below 2000 m.

Sagebrush subspecies were identified by the combined information of three techniques and verified by A. H. Winward, regional ecologist for Range and Watershed Management, USFS Intermountain Region, Ogden, Utah. The first technique involved field identification using morphological characteristics based on keys by A. H. Winward and Tisdale (1977). Leaf samples were taken for the other two procedures. Two-dimensional chromatography, as described by Hanks et al. (1973), was done on persistent overwintering leaves from three plants at each site except site 5, where the morphological variability of the sagebrush plants was greater than at the other sites. At this site five plants were

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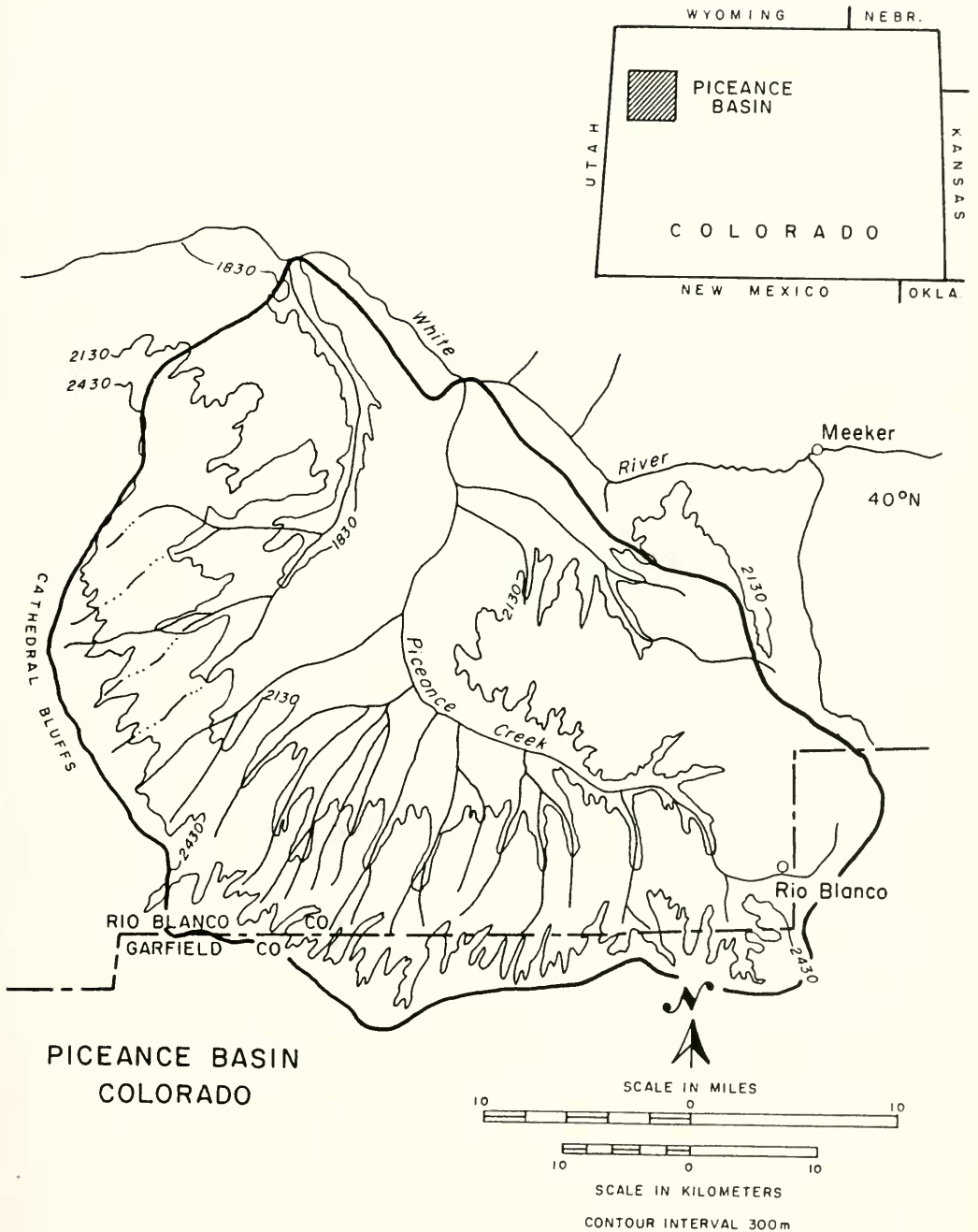


Fig. 1. The study area of the distribution of *Artemisia tridentata* subspecies in northwest Colorado.

tested by chromatography. Results were compared with representative chromatograms. The third procedure was a leaf extract in water. This latter method was performed on all plants tested by chromatography and on a total of approxi-

mately 18 other plants in the study sites. Leaves were crushed by hand and placed in glass containers for four hours. These were viewed under long-wave ultraviolet light and compared to descriptions by Stevens and McArthur (1974).

TABLE 1. Location, elevation, and sagebrush subspecies of study sites. VAS = ssp. *vaseyana*; TRI = ssp. *tridentata*; WYO = ssp. *wyomingensis*. Selected soil characteristics are listed for 0–15 cm and 16–30 cm soil samples for each site.

Location	Site	Elev.	ssp.	Depth in cm	% sand	% silt	pH	CaCO <sub>3</sub> est.
High mountain	1	2365	VAS	0–15	54	26	6.9	low
				15–30	52	26	6.8	low
	2	2585	VAS	0–15	40	33	6.8	low
				15–30	36	33	6.5	low
Valley bottom	3	1957	TRI	0–15	74	13	8.2	med
				15–30	67	20	8.1	med
	4	2057	TRI	0–15	56	30	8.1	med
				15–30	52	32	8.2	med
Upland terrace	5	1920	WYO	0–15	46	27	8.2	med
				15–30	51	27	8.3	med
	6	2070	WYO	0–15	32	45	7.7	med
				15–30	28	44	8.2	med

In each site, soil samples were collected at two random locations from two depths, 0–15 cm and 16–30 cm. These were analyzed for pH, organic matter, electrical conductivity, estimated CaCO<sub>3</sub>, sand, silt, clay, K, Mn, Zn, Cu, P, and Fe. These data were used in a factor analysis as described by Affifi and Clark (1984). The factor scores for each site and depth were then graphed. This graph was used to interpret the axes that usually represent some environmental characteristic associated with plant species.

## RESULTS

Sites 1 and 2 were high mountain sites. Sagebrush plants averaged less than 50 cm in height. Common associated plants were *Lupinus* sp., *Chrysothamnus viscidiflorus*, *Eriogonum umbellatum*, *Stipa lettermanii*, and *Symphoricarpos oreophilus*. Soils were all deeper than 40 cm and dark in color. Near these sites *Populus tremuloides* stands were common in favorable microenvironments.

Sites 3 and 4 were in a valley bottom in the Yellow Creek area. The sagebrush in these sites commonly reached heights greater than 2 m. Associated vegetation included the moss *Tortula ruralis*, *Chenopodium pratericola*, and *Lepidium latifolium*. Soils were light in color, and depths greater than 40 cm were common.

Sites 5 and 6 were at similar elevations to 3 and 4, but away from streams. Sagebrush plants averaged 40 cm in height. Site 5 soils were approximately 10 cm in depth. *Bromus tectorum*, *Gutierrezia sarothrae*, *Alyssum albyssoides*,

and *Oryzopsis hymenoides* were the common plant species. Site 6 soils averaged 20 cm deep. Common understory species were *Koeleria cristata*, *Agropyron smithii*, and *Phlox hoodii*. Site 6 was surrounded by forests of *Pinus edulis* and *Juniperus osteosperma*.

Locations of *A. tridentata* subspecies in the study area relate generally to elevation. The lowest elevations supported both ssp. *wyomingensis* and ssp. *tridentata*. Factor analysis results indicate that soil texture and chemistry differences existed between the sites (Fig. 2). Subspecies *tridentata* was found in sandier soils and *wyomingensis* in siltier soils. The texture differences were generally related to topographic position. Subspecies *tridentata* was most common in valley bottoms, and ssp. *wyomingensis* was typically dominant away from streams, at the lowest elevations to approximately 2100 m. Sites above 2100 m supported ssp. *vaseyana*. Soil textures in *vaseyana* site 1 were similar to those in *tridentata* sites, while *vaseyana* site 2 textures more closely resembled those of the *wyomingensis* sites. Soil pH was lower in the *vaseyana* sites than sites with the other subspecies.

Morphological identification of ssp. *vaseyana* and *tridentata* generally agreed with the results from two-dimensional chromatography and the leaf extracts. Subspecies *wyomingensis* chromatograms were not consistently separable from those of subspecies *tridentata*. None of the *wyomingensis* chromatograms closely matched published chromatograms. Leaf extracts from ssp. *wyomingensis* showed almost no

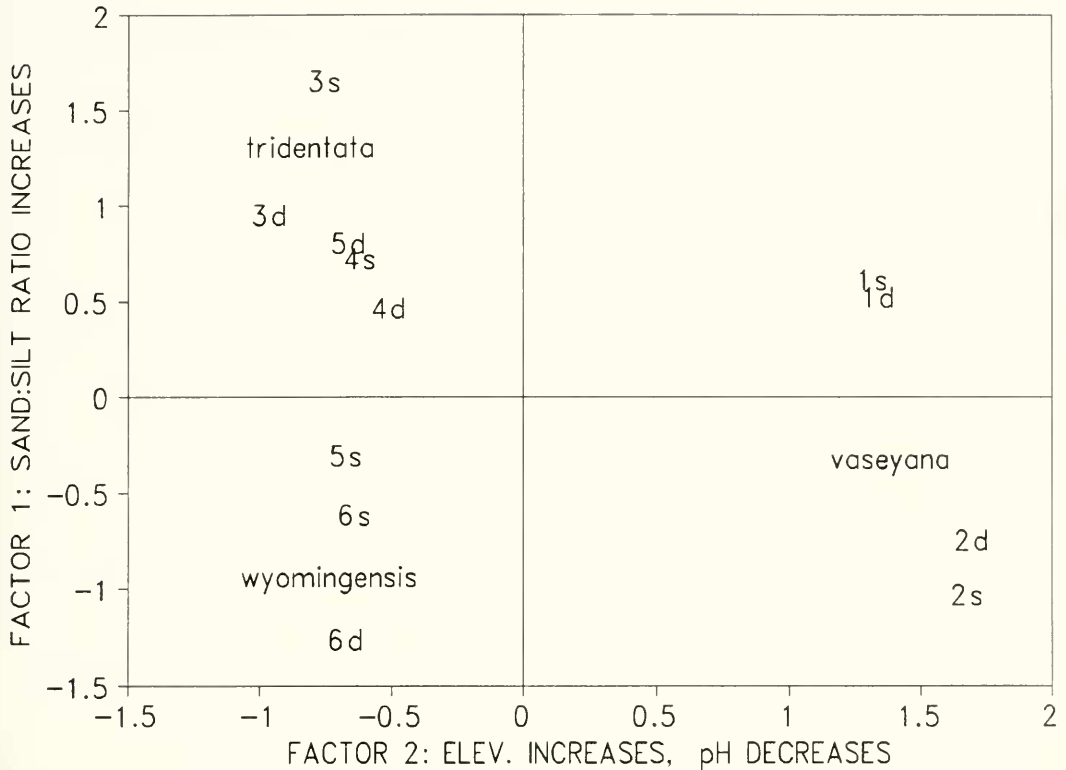


Fig. 2. Results of factor analysis on all soil data. Y axis corresponds to increasing sand:silt ratio; X axis corresponds to decreasing pH. Stand numbers are as in Table 1: s indicates sample from 0–15 cm; d indicates sample from 15–30 cm. Names show approximate region of ordination occupied by each subspecies.

fluorescence and were not separable from ssp. *tridentata*. Morphologically, however, this subspecies was separable from *vaseyana* and *tridentata* by the keys of Winward and Tisdale (1977).

#### DISCUSSION

Three subspecies of *A. tridentata* were identified in the Piceance Basin by reference to morphology, chromatography, and leaf extracts. The subspecies identified were *wyomingensis*, *tridentata*, and *vaseyana*. Two-dimensional chromatography and leaf extracts yielded preliminary evidence to suggest that ssp. *wyomingensis* in the Piceance Basin is chemically different from those previously identified.

The distributions of *A. tridentata* subspecies are generally related to soil moisture, temperature, depth, and parent material (Hironaka 1978). The overall tendency seems to be for ssp. *tridentata* to occupy deep, somewhat sandy soils. Although subspecies *wyomingensis* occurs

in an overlapping zone with *tridentata*, it is more common in shallow, silty soils where moisture stress is greater. Subspecies *vaseyana* occurs in cool, moist sites, usually above 2100 m, but lower elevations have been documented (Goodrich et al. 1985).

Each subspecies was found at elevations and in soil textures similar to those reported in the literature. Soil texture, expressed as a ratio of sand to silt, explains the first factor in the factor analysis and distinguishes between sites of ssp. *tridentata* and *wyomingensis* (Fig. 2). That is, the vertical axis in Figure 2 corresponds to this ratio. It appears that the relative proportion of sand and silt determines whether ssp. *tridentata* or ssp. *wyomingensis* will be dominant. Barker and McKell (1983) reported similar results and suggest that the characteristics of soils associated with these subspecies are different. Fine-textured soils have been implicated in increased water stress in ssp. *wyomingensis* sites (Shumar and Anderson 1986). This might indicate a differential adaptation to water stress and,

consequently, different life history strategies in the subspecies (Bonham et al. 1991).

Soils at sites with ssp. *vaseyana* are distinguished from the other sites by factor 2 of the factor analysis. This axis represents both an elevational and soil pH gradient (Table 1, Fig. 2). Sites with ssp. *vaseyana* were at a higher elevation, and soils were lower in pH and CaCO<sub>3</sub> values. The textures at these sites did not differ substantially from the other sites.

No previous study in the area has identified these taxa or characterized their habitats. The great differences in habitat preference among these subspecies suggest this is a major oversight.

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